

A8

Example 2: Copolymer of 2B and 2A (50:50 ratio, 89wt% in mesitylene)

Please replace the line at page 16, line 20, with the following:

A9

Example 4: Copolymer of 2B and 2C (70:30 ratio, 76wt% in mesitylene)

Please replace the line at page 17, line 26, with the following:

A10

Example 7: Copolymer of 2B and 2A (80:20 ratio, 86wt% in mesitylene)

The preceding replacements correct mathematical errors in the original specification in obtaining the weight percent of copolymer in solution, and do not add new matter to the specification as filed.

REMARKS

Please find included with this response an Appointment of Associate Attorney signed by Attorney of Record John Vick appointing Agent Christina Mangelsen as an associate agent in this matter.

In view of the foregoing Amendments and following remarks, reconsideration and allowance of the present application are respectfully requested.

In general, the present invention is directed to methods of making optical devices and solutions for making optical devices. In particular, the present invention is directed to methods for making optical devices which include providing a perfluorocyclobutyl-based copolymer composition and applying the copolymer composition by a coating method for form a film. For instance, the copolymer film may be a core or a clad of an optical waveguide. As discussed in the application specification, accurate control over the polymer properties (and therefore, the device properties) can be achieved by copolymerization of the disclosed perfluorocyclobutyl-based monomers. In certain embodiments of the present invention, high solids content solutions of the disclosed copolymers may be utilized. High solids content solutions may be advantageously used in the practice of the invention in forming relatively thick films of the copolymer compositions. The ability to form thick coatings can ensure a homogeneous layer in the final structure of the optical devices of the present invention as compared to layers

formed from multiple spin and cure cycles needed otherwise to achieve desired thicknesses.

Currently, claims 1-19, 22-26, 28-30, and 32-48 are pending in the application, including independent claims 1, 16, 28, 29, and 30. In the Office Action, the claims were rejected in regard to the following references: Shah, et al., Hoeglund, et al., Smith, et al., Babb, et al. '164 (U.S. Patent No. 5,426,164), Babb, et al. '038 (U.S. Patent No. 5,159,038), Fischbeck, et al., Shacklette, et al. (U.S. Patent No. 5,850,498), and Kennedy, et al. (U.S. Patent No. 5,246,782).

Independent claims 1, 16, and 29, as presently amended, are directed to a method of making an optical device including providing a perfluorocyclobutyl-based copolymer composition having a solids content greater than 50%. Independent claim 30, as presently amended, is directed to a solution for making an optical device comprising a perfluorocyclobutyl-based copolymer having a solids composition of greater than 50%. The Applicants respectfully submit that these amended claims are fully supported throughout the specification as filed and the amendments add no new matter to the application. For example, Table 2 at page 14 of the specification discloses specific examples of copolymer solutions at 50wt%, 70wt%, 75wt%, 76wt%, 86wt% and 89wt%.

Applicants respectfully submit that the presently amended claims including the limitation of a PFCB copolymer composition comprising greater than 50% solids content by weight are patentably distinct over the prior art of record. As discussed in the application at the paragraph beginning at page 8, line 11, it has been surprisingly discovered in the practice of the invention that compositions formed from the structures of the Figures may be advantageously used to provide high solids content solutions for coating on substrates. That is, prior to the experimental results obtained in the disclosure, it was not expected that the copolymer solutions of the invention could be formed at such high solids content.

As pointed out by the Examiner in the Office Action, there are other references which disclose PFCB copolymer solutions and crosslinked PFCB copolymer networks. Specifically, Smith, et al., Babb, et al. '164 and Babb, et al., '038 each teach some form of PFCB copolymers. In addition, Kennedy, et al. discloses PFCB homopolymer networks formed from homopolymer solutions at greater than 50wt% solids content. However, Applicants respectfully submit that none of these references disclose or suggest a copolymer solution which is at a solids content of greater than 50wt%. In addition, Applicants further submit that no motivation is found in the references for combining the teachings of Kennedy, et al., which teaches a high solids content solution of a homopolymer, with the teachings of any of Smith, et al., Babb, et al. '038, or Babb, et al. '164, each of which discloses a PFCB copolymer, in order to arrive at the high solids content solutions comprising PFCB copolymers as are taught in the present invention which can be used to obtain thick films, e.g., at least about 0.6 microns.

Smith, et al., in Section 2.4. of the article titled, 'Optical fiber and waveguides,' discusses the copolymerization of PFCB monomers. However, as pointed out in the second paragraph of that section, the cyclopolymerization rate difference of the monomers were first investigated, prior to formation of the copolymers. Monomers, even when similar in structure, have different reactivities due to solubilities, stereochemistry, and functionality, as well as other differences in basic chemistry. Smith, et al. examined these different chemistries of the monomers prior to attempting to form the copolymers. As the chemistries of the individual monomers are different, it necessarily follows that the chemistry of the copolymer formed from two monomers will be different from the chemistry of either homopolymer. In other words, as the thermodynamic properties, the optical properties, the mechanical properties, the reaction kinetics, the functionalities, the stereochemistry, the solubilities, in fact the very nature of a copolymer is different from the homopolymers formed from the same monomers, it would follow that the characteristics of homopolymer solutions, such as

those taught in Kennedy, et al., will be different from the characteristics of copolymer solutions formed from the monomers. As such, it would not be obvious to prepare solutions of the copolymers as taught in any of Smith, et al., Babb, et al. '038, or Babb, et al. '164 in the same manner as solutions of the homopolymers were prepared as taught in Kennedy, et al. Therefore, Applicants respectfully submit that it would not be obvious to combine the teachings of Kennedy, et al., directed to homopolymer solutions, with the copolymers of any of Smith, et al., Babb, et al. '038, or Babb, et al. '164, as suggested in the Office Action, and as such, the present claims directed to high solids content PFCB copolymer compositions patentably define over the prior art of record.

Furthermore, Babb, et al. '038 includes two examples of copolymer formation. Example 10 (col. 18, line 1 – col. 19, line 50) illustrates preparation of 1,1,1-tris(4'trifluorovinyloxyphenyl)ethane and copolymerization thereof with 4,4'-bis(trifluorovinyloxy)biphenyl. According to Babb, et al. '038, however, the resulting polymer is stiff and brittle, compared to the flexible homopolymer prepared from 4,4'-bis(trifluorovinyloxy)biphenyl alone in Example 2 of the patent. Thus, Applicants further submit that Babb, et al. '038 actually teaches away from this particular type of copolymer in favor of the disclosed homopolymer compositions. Thus, not only would it not be obvious to combine the teachings of Babb, et al. '038 with Kennedy, et al., as discussed above, but Babb, et al. '038 actually teaches away from such a combination, as the copolymer of Babb, et al. '038, as illustrated in Example 10, is not particularly well-suited for the desired uses.

In the Office Action, the independent claims were rejected under either 35 USC 102(b) as anticipated by, or alternatively under 35 USC 103(a) as obvious over Smith, et al. Smith, et al. in general discusses the combination of processability and performance provided by PFCB polymers, and their resulting wide range of possible applications (first column of the article). In the Office Action, the Examiner pointed out the description in Smith, et al. of spin coating oligomeric solutions to form thick films, for

example 3-6 microns, and then finally curing the films by baking at 235-325°C under air or nitrogen. Applicants find this description in Section 2.1. of the article, titled 'Traditional PFCB coatings materials.' This section of Smith, et al. describes how traditional TFVE monomers are prepared in two steps from commercially available phenolic precursors via fluoroalkylation.

More specifically, the description of thick film formation pointed out by the Examiner is found in the first two full paragraphs of the fourth column of the article. In the paragraphs at question, Smith, et al. teaches that the monomer can be solution advanced at 150°C in typical solvents to a precisely controlled viscosity, molecular weight, and polydispersity. Moreover, in the second paragraph, Smith, et al. discusses the polymerization kinetics for a monomer. According to the article, "Fig. 1 compares the Raman spectra of pure monomer 1, an oligomeric film spin coated from mesitylene solution on silicon, and the fully cured film (3-6 µm in thickness)." Thus, the paragraph discusses the pure monomer, the monomer partially advanced (to an oligomer), and the cured homopolymer film. Applicants submit that the descriptions of film formation in these paragraphs are directed to monomer solutions and thus homopolymer films, rather than the thick copolymer films and high solids content copolymer solutions as are taught in the present invention. The paragraphs in question do not disclose or suggest a PFCB copolymer film at the disclosed thickness of 3-6 µm.

In the Office Action, Fischbeck, et al. was also cited as disclosing thick PFCB polymer films. However, and similar to Smith, et al., Fischbeck, et al., which discloses PFCB films of polymerized 1,1,1-tris(4'-trifluorovinyloxyphenyl) ethane of up to 10µm thickness, does not disclose or suggest PFCB copolymer films at such a thickness. Moreover, and for at least the reasons discussed above in regard to solids content of the copolymer solutions, Applicants submit that the ability to form a thick film of a homopolymer does not render obvious the ability to form a thick film of a copolymer which comprises monomers found in the homopolymer film.

Independent claims 28 and 29, as presently amended, are directed to a method of making an optical device wherein a perfluorocyclobutyl-based copolymer composition may be spin coated upon a substrate to form a first film, wherein the first film forms a substantially transparent core. As discussed in the specification, an optical waveguide typically comprises a transparent core that is capable of directing light signals therethrough, and a cladding comprising a material that affords a lower refractive index than the core material (page 2, lines 22-24). Through the copolymerization of different PFCB monomers, as taught in the present invention, accurate control over the polymer properties may be achieved. Due to this accurate control, i.e. the ability to 'tune' the properties of the polymers, it is possible to copolymerize specific comonomers according to the processes of the present invention to provide variable and relatively thick core copolymers as well as clad copolymers (page 8, lines 21-24).

In the past, a large variety of materials have been suggested as possible for use in optical devices. For instance, according to Shacklette, et al., the compositions used to form each of the cladding and core comprise a photopolymerizable compound and a photoinitiator. Multifunctional acrylate monomers are preferred, and low glass transition temperature polymers are specifically taught (col. 5, lines 29-64). Shacklette, et al., however, does not disclose or suggest PFCB materials as possible materials for either the core or the clad of an optical device. In fact, the core materials of Shacklette, et al. are disclosed as having a glass transition temperature of about 80°C or less, and the clad materials are disclosed as having a glass transition temperature of about 60°C or less. Thus, Shacklette, et al. clearly teaches away from the suitability of high glass transition temperature materials, such as PFCB materials, for example, as either core or clad materials.

The other references cited in the Office Action disclose PFCB materials as possible materials for use in optical devices as well as other devices. For example, the PFCB polymers described by Smith, et al. are disclosed as natural candidates for

optical cladding layers (first column of the article). The PFCB homopolymer materials of Kennedy, et al. may also be useful as optical cladding (col. 4, line 30). The PFCB materials of Babb, et al. '038 are disclosed as low dielectric fluids and lubricants, as well as low dielectric plastics (col. 2, line 67 – col. 3, line 15). The photoactive polymers prepared by Babb, et al. '164 are advantageously used as coatings (col. 20, line 14). Shah, et al., Hoeglund, et al., and Fischbeck, et al. all disclose PFCB materials as materials suitable for optical applications. However, none of the references cited disclose or suggest PFCB copolymer materials as possible materials for the core of a core/clad optical device. As such, Applicants respectfully submit that the present claims directed to a PFCB copolymer solution for use in forming a core for an optical device patentably define over the prior art of record.

In the office Action, the above-cited references were also cited in various combinations to reject the dependent claims. Applicant respectfully submits, however, that at least for the reasons indicated above relating to corresponding independent claims 1, 16, 28, 29, and 30, the currently pending dependent claims patentably define over the references cited. However, Applicant also notes that the patentability of the dependent claims does not hinge on the patentability of independent claims 1, 16, 28, 29, or 30. In particular, the dependent claims possess features that are independently patentable, regardless of the patentability of claims 1, 16, 28, 29, and 30.

It is believed that the present application is in complete condition for allowance and favorable action, therefore, is respectfully requested. Examiner Angebrannndt is invited and encouraged to telephone the undersigned, however, should any issues remain after consideration of this response.

Please charge any additional fees required by this Amendment to Deposit Account No. 04-1403.

Respectfully submitted,

DORITY & MANNING, P.A.

A handwritten signature in cursive script, reading "Christina L. Mangelsen".

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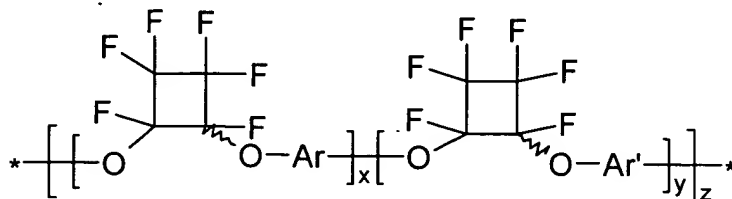
Appendix A

Amended claims with changes marked:

1. (Amended) A method of making an optical device, comprising:

(a) providing a copolymer composition having a solids content of greater than 50% [of], the composition containing a copolymer having the structural formula:

[for Ar \neq Ar']



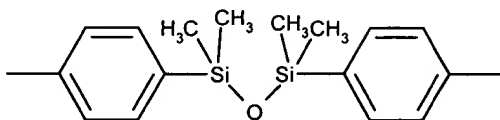
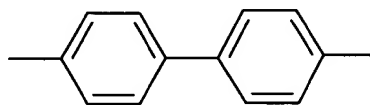
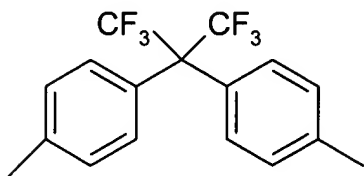
wherein Ar does not equal Ar',

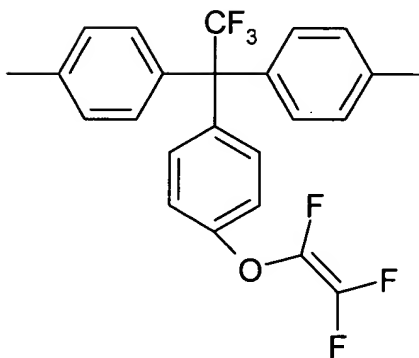
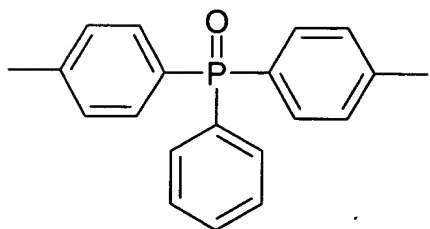
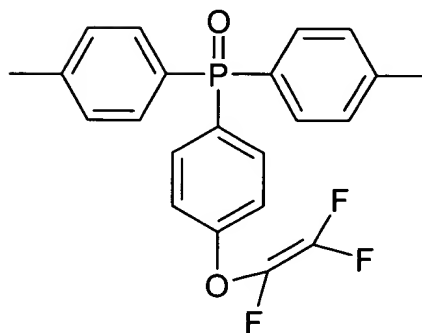
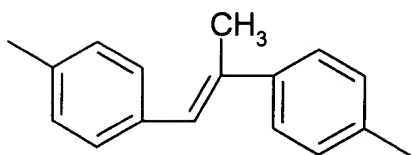
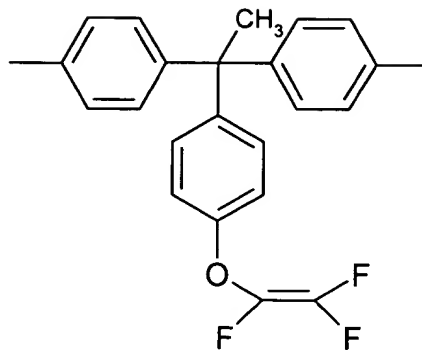
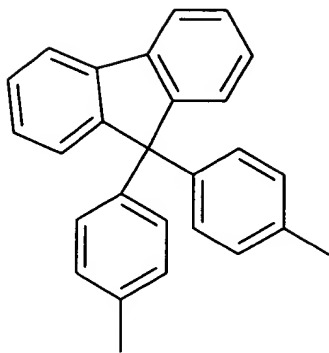
wherein z is greater than or equal to 2, and

wherein x and y each are greater than or equal to 1, respectively,

and

wherein the Ar and the Ar' groups each comprise substituted or nonsubstituted aryls selected from the group comprising:





(b) applying the copolymer composition by coating to form a first film.

2. (Amended) The method of claim 1 in which [the copolymer is prepared from] at least one of Ar and Ar' is a trifluorovinyl aromatic ether.

6. (Amended) The method of claim 1 comprising the additional step of[:

(c)] thermally curing the first film to form a cured thermoset film.

16. (Amended) A method of making an optical device, comprising:

(a) providing a perfluorocyclobutyl-based copolymer composition having a solids content of greater than 50%,

(b) coating the perfluorocyclobutyl-based copolymer composition upon a substrate to form a first film, and

(c) thermally curing the first film to form a thermoset film.

17. (Amended) The method of claim 16 in which the thermoset film comprises a substantially transparent polymeric core of an optical waveguide.

18. (Amended) The method of claim 17 comprising the additional step of:
(d)] applying cladding comprising a perfluorocyclobutyl-based copolymer to the outer surface of the core [to form an optical waveguide].

28. (Amended) A method of making an optical device, comprising:

(a) providing a first perfluorocyclobutyl-based copolymer composition,

(b) spin coating the first perfluorocyclobutyl-based copolymer composition upon a substrate to form a first film[, and

(c) thermally curing the first film to form a first cured film having a thickness of at least about 2 micron], wherein the first film forms a substantially transparent polymeric core,

(d) providing a second perfluorocyclobutyl-based copolymer composition different than the first perfluorocyclobutyl-based copolymer composition, and

(e) spin coating the second perfluorocyclobutyl-based copolymer composition upon the first film, wherein the second film forms a polymeric clad.

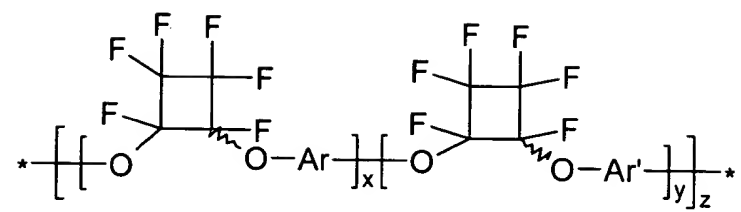
29. (Amended) An optical device constructed by the method of:

(a) providing a perfluorocyclobutyl-based copolymer composition having a solids content of [at least about] greater than 50%,

(b) spin coating the perfluorocyclobutyl-based copolymer composition upon a substrate to form a first film, [and

(c) thermally curing the first film to form] wherein the first film forms a core for an optical device[, thereby forming an optical device] having a cured film thickness of at least about 0.6 microns.

30. (Amended) A solution for making an optical device in which the solution comprises a perfluorocyclobutyl-based copolymer having a solids composition of greater than 50%, the copolymer having the structural formula:



where Ar does not equal Ar',

wherein z is greater than or equal to 2, and

wherein x and y each are greater than or equal to 1, respectively.

Appendix B

Amended specification paragraphs with changes marked:

Paragraph beginning at page 10, line 14:

Solids content of solution of PFCB copolymer employed may be from about 10% to about 70%. Films [films] or plaques can be prepared by melt-mixing variable composition monomer mixtures and heating at 150°C-200°C under an inert atmosphere.

Table 2, at page 14:

Table 2 Selected Copolymer Data

Ex.	Monomer (g)	Monomer (g)	wt.% polymer in mesitylene	Polym. time (h) at 150/160 °C	Mn	Mw	Mw/Mn	Olefin conv. (%)	Viscosity (Pa.s)	*Refractive index @1550 nm	*Glass Transition, Tg (°C)
1	2B(175)	0	75	1.45	2444	7033	2.89	34.8	0.1	1.4883	350
2	2B(40)	2A(40)	89[80]	2.5	589	1212	2.06	37.3	0.133	1.5036	225
3	2B(17.38)	2C(7.78)	50	8	1859	4656	2.5	44.2	6.8	1.4785	221
4	2B(17.38)	2C(7.78)	76[75]	5	3943	9709	2.45	52.2	1.575	1.4801	220
5	2B(50)	2A(50)	70	2.15	661	1178	1.78	37	1.1	1.5008	224
6	2B(160)	2A(40)	75	3.2	2508	4846	1.93	40	0.1	1.4892	285
7	2B(80)	2A(20)	86[70]	1.45	899	2008	2.34	32	0.085	1.4892	286

*After cure at 200 °C for 2 h.

Page 15, line 28:

Example 2: Copolymer of 2B and 2A (50:50 ratio, [80] 89wt% in mesitylene)

Page 16, line 20:

Example 4: Copolymer of 2B and 2C (70:30 ratio, [75]76wt% in mesitylene)

Page 17, line 26:

Example 7: Copolymer of 2B and 2A (80:20 ratio, [70]86wt% in mesitylene)